1. (a) uniform acceleration

allow constant / steady acceleration
allow velocity / speed increasing at a constant rate
ignore reference to direction
*acceleration scores **1** mark*
or
*velocity / speed is increasing scores **1** mark*
*do **not** accept acceleration increases*

2

(b) up(wards)

1

(c) a group of objects that interact

1

(d) velocity just after bounce is less than just before bounce

allow velocity is less / decreases
velocity decreases to zero − on its own scores zero

or

the height at the top of the bounce is less than the height from which it was dropped

1

so the ball has lost energy

1

correct reference to (loss of) ke or (reduced) gpe

1

total energy of ball and Earth / ground is constant

allow 'a system' for ball and Earth
allow energy is conserved

1

[8]

2. (a) wavelength

this answer only

1

(b) (extremely) hot and dense

ignore very small

1

(c) (directly) proportional

allow a correct description of direct proportionality
ignore positive correlation

1

(d) 6×10^{24}

1

(e) the furthest galaxies are moving the fastest

1

(this suggests) the universe is expanding (from a very small region)

1

(f) expanding at (an ever) greater rate

allow expanding faster

1

(g) any **one** from:

- detects false claims

  allow provides credibility
- detects inaccurate data

  allow detects mistakes
- detects bias

  allow removes bias
- verifies new data

  allow checks validity
- provides a consensus (of opinion)

  ignore shows data is accurate
  ignore proves a theory

1

(h) wavelength (seems to have) decreased

1

frequency (seems to have) increased

1

[10]

3. (a) P-waves are longitudinal and
S-waves are transverse

1

(b) 0.4

1

(c) wave speed = frequency × wavelength

allow $v = f\lambda$

1

(d) 7200 = 0.4 × wavelength

1

$$\text{wavelength} = \frac{7200}{0.4}$$

1

wavelength = 18 000 (m)

*allow up to full marks for ecf using their answer to part **(b)***

a method shown as
7200 × 2.5 = 18 000
*scores **0** marks*

1

*an answer 18 000 scores **3** marks*

(e) because S-waves cannot travel through a liquid

1

and S-waves do not travel through the (outer) core

*allow some (seismic) waves cannot travel through a liquid and do not go through the core for **1** mark*

1

(f) magnetic field around the coil changes
or
the magnetic field (lines) cut by the coil

allow the generator effect

1

(g) because the magnet changes direction

1

(h) stationary

1

(i) any **two** from:

- stronger magnetic field

  allow stronger magnet
  allow heavier magnet
  bigger magnet is insufficient

- more turns on the coil

  bigger coil is insufficient
  *do **not** accept more coils of wire*

- turns pushed closer together

- spring with a lower spring constant

  allow less stiff spring
  allow weaker spring
  *do **not** accept add an iron core*

2

[13]

4. (a) all heights drawn the same as tube 1

judge by eye

1

(b) increasing depth increases the height / mass / volume (of the water column) above the swimmer

allow more water above (the swimmer)
more water is insufficient

1

increasing the weight / force (of water) acting on the swimmer

1

(c) increase in depth = 1.2 (m)

1

(Δ) p = 1.2 × 1030 × 9.8

*allow either 0.50 **or** 1.70 for 1.2*

1

(Δ) p = 12112.8

allow a correctly rounded answer
*allow a correct calculation using either 0.50 **or** 1.70*

1

pascals **or** Pa

*do **not** accept pa*
allow N/m^2

1

*an answer of 12 112.8 scores **3** marks*

[7]

5.

(a) random

human error is insufficient

1

(b) accept any practical suggestion that could cause a range of values
e.g. misjudging the centre of the ray
e.g. not replacing mirror / ray box in the same position

measuring the angle incorrectly is insufficient
moving the mirror / ray box is insufficient

1

(c) range = 10
or
mean of 51 calculated

1

5(°)

*an answer of 5(°) scores **2** marks*

1

(d) within experimental accuracy the angle of incidence and the angle of reflection are the same

allow the angle of incidence is nearly the same as the angle of reflection

or
the angle of reflection is usually different to the angle of incidence

allow only a few of the values are the same / similar
allow the idea of a range of values

1

relevant use of data
e.g.
at 20° / 30° / 40° there is at least one measurement of angle of reflection that is exactly the same
or
at 50° there are big differences

allow 50° includes anomalous results

an answer in terms of calculated mean(s) may score both marks
e.g.
mean calculated for one or more angle of reflection (1)
conclusion correctly stating angle i = / ≠ angle r (1)

1

(e) results could be collected for angles (of incidence) not yet measured

allow a stated angle of incidence e.g. 10° or 60°

changing the mirror is insufficient
ignore repeat the measurements

1

(f) replace the mirror with an irregular reflecting surface

allow use an irregular reflecting surface
replace mirror with paper is insufficient
*do **not** accept use a glass block*

1

[8]

6. (a) arrow of equal size pointing vertically upwards

judged by eye
ignore horizontal arrows if equal and opposite
horizontal arrows of unequal length negates this mark

1

labelled 'upthrust'

ignore buoyancy
ignore 25 kN

1

(b) weight = 25 kN

allow 24 to 25 kN inclusive

1

25 000 = mass × 9.8
or
$m = \frac{25000}{9.8}$

allow their W correctly converted and substituted

1

m = 2551 kg

allow correctly calculated value using their converted W
allow a value correctly calculated with W in kN

1

m = 2600 kg

allow a calculated answer correctly rounded to 2 significant figures

1

*an answer of 2600 scores **4** marks*

(c) Newton's 3rd law (of motion)

1

(d) vertical force (50 N) drawn
and
horizontal force (150 N) drawn to the same scale

1

resultant tension force in the correct direction

shown by an arrowhead

1

value of the tension force in the range 156 N−160 N

allow a calculated value of 158

1

value of direction in the range 18°−20° (from the horizontal)

allow 70° to 72° (from the vertical)
allow a bearing in the range 288 to 290

1

[11]

7. (a) any **one** from:

- too few turns / coils on the secondary

  allow number of turns / coils on the primary was increased

- p.d. across the primary was reduced

  ignore human error

1

(b) the p.d. (across the secondary) goes above 2V

allow p.d. across secondary is higher than p.d. across primary after 20 turns

1

(c) it increases (until the nails reach a constant temperature)

1

(d) $\frac{640}{4} = \frac{V_p}{1.75}$

1

$V_p = \frac{640 \times 1.75}{4}$

1

$V_p = 280$ (V)

1

$280 \times I_p = 336$

allow their calculated
$V_p \times I_p = 336$

1

$I_p = 1.2$ (A)

allow an answer that is consistent with their calculated value of V_p

1

or

$336 = I_s \times 1.75$ (1)

$I_s = \frac{336}{1.75}$ (1)

$I_s = 192$ (A) (1)

$I_p = 192 \times \frac{4}{640}$ (1)

allow

$I_p =$ their calculated $I_s \times \frac{4}{640}$

$I_p = 1.2$ (A) (1)

allow an answer that is consistent with their calculated value of I_s

*an answer of 1.2 (A) scores **5** marks*

[8]

8. (a) (force of) gravity causes the satellite to accelerate (towards the Earth)

allow satellite is (constantly) accelerating

1

the acceleration causes a change in direction

acceleration causes a change in speed negates this mark point

1

velocity changes because direction changes

1

(b) length of orbit taken from graph = 42 100 (km)

1

42 100 = 7.73 × time

or

$$\text{time} = \frac{42100}{7.73}$$

allow

their distance = 7.73 × time

1

time (1 orbit) = 5446(s)

allow a value consistent with their distance

1

$$\text{number of orbits} = \left(\frac{24 \times 3600}{5446}\right)$$

= 15.86

allow $\left(\frac{24}{1.51}\right) = 15.86$

allow a value consistent with their distance

1

number of orbits = 15

allow a value consistent with their distance

*an answer of 16 scores **4** marks*

1

or

length of orbit taken from graph = 42 100 (km) (1)

$$7.73 = \frac{\text{distance}}{24 \times 3600}$$ (1)

distance = 667 872 (km) (1)

$$\text{number of orbits} = \left(\frac{667872}{42100}\right)$$

= 15.86 (1)

allow a value consistent with their two distances

number of orbits = 15 (1)

allow a value consistent with their two distances
up to full marks can be awarded for a method calculating velocity in km/h and time in hours
*an answer of 15 scores **5** marks*

(c) the predicted data is very close to the actual data

1

(d) supported the prediction (made by Bode)

allow predicted and actual values are very close

1

so provides evidence that the equation is true / correct / works / accurate

allow proves for provides evidence

1

[11]

9. (a) it is harder to judge where the centre of a wider ray is

1

causing a larger uncertainty (in the measurements)

allow increasing <u>random</u> errors (in the measurements)

1

(b) line of best fit drawn and extrapolated to 80 degrees

1

41 (degrees)

allow 40 to 43 (degrees)

1

(c) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content:

- place a glass block on a piece of paper
- draw around the glass block
- use the ray box to shine a ray of light through the glass block
- mark the ray of light entering the glass block
- mark the ray of light emerging from the glass block
- join the points to show the path of the complete ray through the block
- and draw a normal line at 90 degrees to the surface
- use a protractor to measure the angle of incidence
- use a protractor to measure the angle of refraction
- use a ray box to shine a ray of light at a range of different angles (of incidence)
- increase the angle of incidence in 10 degree intervals
- from an angle of incidence of 10 degrees to an angle of incidence of 70 degrees.

allow use of optical pins instead of a ray box

(d) $\frac{(28 + 25 + 22)}{3} = 25$

1

3 (degrees)

allow alternative method

28 – 22 = 6 (1)

= 3 (degrees) (1)

1

(e) Velocity

1

[13]

10. (a) at least three circles drawn

1

clockwise arrows on circles

*allow **1** mark for one or two circles with clockwise arrows*

1

(b) 4×10^{-6}

1

(c) the sides of the coil (parallel to the magnet) experience a force (in opposite directions)

allow the current creates a magnetic field
ignore Fleming's Left Hand Rule

1

the forces cause moments that act in the same (clockwise / anticlockwise) direction
or
the moments cause the coil to rotate (clockwise / anticlockwise)

allow the magnetic fields interact to create a pair of forces (acting in opposite directions)
or
allow the magnetic fields interact causing the coil to rotate

1

(each half-revolution) the two halves of the (rotating) commutator swap from one (carbon) brush to the other

1

(each half-revolution) the commutator reverses the current (in the coil)
or
keeping the forces in the same direction (keeping the coil rotating)

allow keeps the current in the same direction relative to the (permanent) magnetic field

1

[7]